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Research on the Safety Risk Structure and Early Warning System of Agriculture

----- With Illustrations of Production of Live pigs to Farmers

Weidong Xi[a,b,]*, Yonghai Sun[b] , Xiaona Tian[a] , Hongying Wang[a] , Qingfen Jin[a]

[a] *College of Economics and Management, NorthEast DianLi University,Jilin 132012, CHN*
[b] *College of Biological and Agricultural Engineering, Jilin University,Changchun 130022, CHN*

Abstract

The paper proposes the quality risk of the formation mechanism and risk structure of agricultural production, process and product , and establishes quality and risk systems of the "2-3 structure" mode of agricultural products; with the production of live pigs to farmers as an example. We use the Rough set theory and MATLAB tool to extract a sample of data-oriented implicit risk , seek for the decision-making knowledge rule, and verify the "2-3 structure" model of quality and risk of agricultural products. On the basis of it, three types of risk will be essential to theory of Calibration Risk， infrastructure risk and credit risk. The raised risk tree shows the high probability of the risk derivation. According to the model, using the Fishbone diagram and the AHP, it establishes modular system of safety assessment of agricultural products, and designs the early-warning indicator system to make up the deficiencies of the HACCP, GAP, and GMP methods. Using the proposed amendments G_1-model in combination with expert data the paper gives factor levels of agricultural production systems module; it proposes the "membership degree frequency method" for regional safety assessment and early warning of agricultural products. Using sampling data of pig breeding farmers in Jilin, we verify evaluation index system and the validity of method presented in this paper.

Keywords: agricultural; risk structure; safety assessment; warning;

1. Introduction

We make a scientific evaluation of the risk status of the quality of agricultural products, determine the causes of all kinds of quality risks, and then adopt a scientific decision, which is the key way to protect the agricultural products from toxic and hazardous substances. The assessment of the risk of quality and the early warning, taken in the past time and based on the current HACCP, GAP, GMP and their derivative criteria in related industries, have

* Corresponding author. Tel.: +86-432-64806853; fax: +86-432-64806629.
E-mail address: xiweidong1964@sohu.com

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made some achievements, however, they also give kinds of risky entrances to the toxic and hazardous substances. The way of the past one is determined, it just can assess single object and work in the limited way.

2. The forming mechanism and structure of the risk of quality in the process of agricultural production

2.1. Definitions of terms and their relationships

Hazard is something that causes harms and injuries to our health, including the unscientific process, unscientific operating norms and so on.

Risk brings about the adverse effects to human and society , which exist in the present prevention and control condition because of the time lag in science and technology, incomplete morality, commercialization of science and technology and the nondeterminacy of nature and human beings' behaviors.

Safety, in a broad sense, refers to a function which eliminates hazards and prevents risks; narrowly referring to those agricultural products which might not contain hazardous substances damaging the health of humans.

Quality means that product has a set of inherent characteristics to meet demand of people and is not dangerous to our health.

Danger means that there is one people have to face injury and damage, which can be prevented through the existing knowledge and methods.

Hazard exists objectively, is a risky factor and enters the object and the object systems because of the uncertainty of the activities of nature and people. Safety is a tool system to identify hazard and prevent risks. It contains quality standard system, facilities systems and regulatory systems, all of which are established in a technological way. Risk is the origin of the danger, and it can be removed because of our knowledge of science and technology, otherwise, it will remain in the human beings' living area. Safety, risk and, danger are neither opposite nor this one or that one, ever nor one containing another. Safety is a system of filtering. Risk and danger are the objects. The relationships of the terms are shown in Fig. 1.

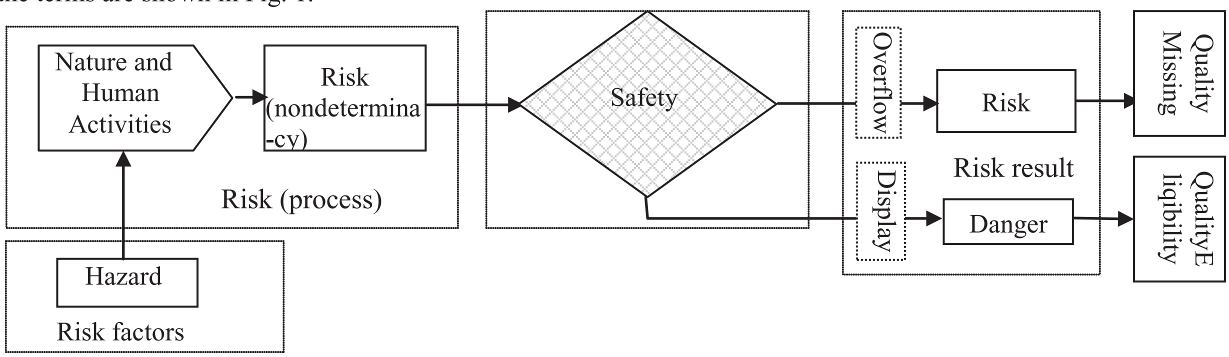

Fig.1. Logical relationship between terms

2.2. Data mining of the rule of risk-oriented decision

This paper, taking farmers pig raising as an example, analyses the decisive rule of the quality of the agricultural product. The sampling frame extends outward 10 kms away form the inter-city. The sampling frame contains 208 chemical enterprises, including 1 large-scale smelting, 1 cement, 1 carbon, 1 paper, 1 automobile manufacturing, and 1 thermal power plant and 3 small and medium thermal power plants. These enterprises distribute along the Second Songhua River. The designing of data collection project includes feeding material (feed, additives, veterinary drugs, etc.), breeding process and environmental properties and so on. The size of

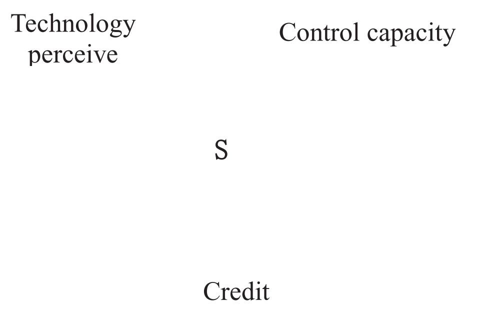

Fig.2. Nondeterminacy and its version

the sample is152 and there are 70 investigative projects.

According to the fuzzy-rough set theory(Pawlak Z, 1994;Pawlak Z, 1998), we choose condition attributes as a standard for feeding material, farmers individual attributes and production environment. We use MATLAB to evaluate the samples' decisions, only 78.42% of which meet 13 out of those 64 decisive rules (Xi Weidong et al., 2009).

2.3. The 2-3 structure and derivatives of risk

According to the analysis of the 13 decisive rules, we find that the basic driving forces of derivatives of risk depend upon whether the producers know the consequences of hazards, whether they assume responsibility for the health of others, and whether they can remove the hazards. The incomplete technological knowledge of hazards, lack of credit and the disability of prevention and control make up the three-dimensional structure, shown as Fig. 2. S means the complete awareness, credit and the capacity of control, while others means incomplete awareness. Uncertainty in Fig. 2 corresponds to risk aversion paradigm that follows the formula:

$$\begin{aligned} &\min \ Risk = R\,(\vec{C}_{cognition}, \vec{C}_{credit}, \vec{C}_{\inf rastructure}) \\ &s.t. \ Ctrl\,(R) = Ctrl\,(\vec{C}_{cognition}, \vec{C}_{credit}, \vec{C}_{\inf rastructure}) \end{aligned} \quad (1)$$

Type $\vec{C}_*$ is the three types of risk source.

From the production point of view, we can see three types of risk from Fig. 2 and equation (1): credit (moral) risk with the product of confidence(An Yufa, 2005), agricultural product being the typical confident product, the risk of physico-chemical facilities and technical prevention, which originate from that facilities. Referent environment can not meet the state health and quarantine standards therefore planting and breeding technology is unscientific, and there is the risk of the knowledge of technology, stemming from the lack of knowledge of hazards, scientific planting and breeding, disease prevention and health awareness, and regulations and quality standards.

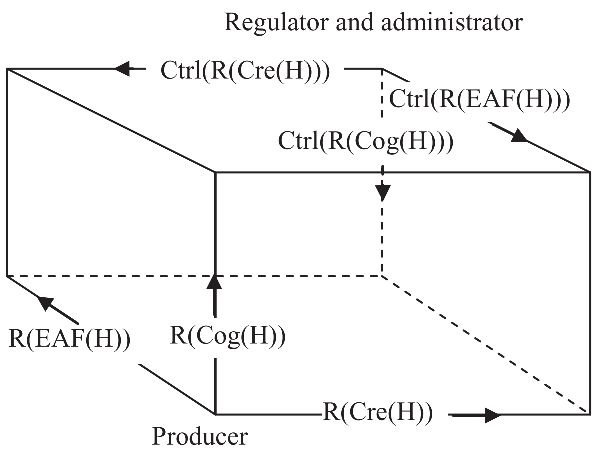

Fig.3. Agricultural risk-box

There are also three similar types of risks in the market supervisions: the credit risk associated with moral failure on the responsibility and supervision, the risk of the capacity of control owing to the inadequacy of the quality control technology and of the facilities, and the risk of the lag of the quality control standard which is based science and technology lags behind the commercialization of technology.

Two kinds of main parts - producers and regulators, and three kinds of risks constitute "2-3 structure" of the agricultural product and form "Risk box " shown in Fig. 3. The risk derivatives paradigm embodied in this risk box is as type (2) as follows:

$$\begin{cases} Ctrl^{cognition}_{\mathrm{Re}gulator\ and\ ad\min istrator} = Ctrl(R_{\mathrm{Pr}oducer}(Cog(H))) \\ Ctrl^{equipment\ and\ facilities}_{\mathrm{Re}gulator\ and\ ad\min istrator} = Ctrl(R_{\mathrm{Pr}oducer}(EAF(H))) \\ Ctrl^{credit}_{\mathrm{Re}gulator\ and\ ad\min istrator} = Ctrl(R_{\mathrm{Pr}oducer}(Cre(H))) \end{cases} \quad (2)$$

Formula:

$Ctrl(R_{\mathrm{Pr}oducer}(Cog(H)))$ —Cognitive Science and Technology Risk Control

$Ctrl(R_{\mathrm{Pr}oducer}(EAF(H)))$ — Prevention and control of equipment and facilities, risk control ability

$Ctrl(R_{\mathrm{Pr}oducer}(Cre(H)))$ —Credit Risk Control

H — hazard

In the absence of the effective quality control, we can see through the risk box that the classical probability of the spread of the quality risk of agricultural product is as high as 87.5%.

3. The quality and safety framework for pattern analysis

3.1. Agricultural Risk Behavior

Subdivided into four kinds of risk of three types of risk behavior：

Theory of risk, also known as the basis of risk, is the awareness of science and technology that lags behind its commercialization. The actual use of the scientific quality standard system has not yet qualified the toxic and hazardous substances Toxicology and thresholds.

Calibration of risk, from farm operators on the standard system for toxic and hazardous substances to meet international standards limit rate, is low. The risks are technical and theoretical risks.

Equipment and facilities, risk prevention and control capabilities are considered from a variety of control hazards elements' technical capabilities and lack equipment and facilities

Credit risk: from operators, government regulators and consumers of product quality in sense of information asymmetry, the operator benefits or reduces the production and marketing in the process of creating a "risk."

Clearly, the theoretical risk is not controllable, and therefore the actual risk control object is in the latter three.

3.2. For "2-3 structure" of agricultural products quality and safety framework

Quality of agricultural products depends on its production system "filter" risks. Therefore, based on the above-mentioned three kinds of risk, it can be constructed of state control over agricultural production systems model of risk. It is easier to identify the risk sources and risk control, and agricultural production systems security architecture is modular.

Module frame design adopted a fishbone diagram (Fishbone Diagram) analysis and AHP (Analytic Hierarchy Process) method. The former will have a causal relationship whereby an object is decomposed into functional modules, which will be assembled as a hierarchy, through both of which the module structure and level of technology to achieve an orderly state.

The "2-3 structure" and the use of Cartesian product form of the modular system made of three-dimensional structure are shown in Fig. 4. The figure shows that the module is based on "Production factor dimension - Process dimension - Risk-dimensional" consisting of three-dimensional space. In theory, the modular system includes 36 sub-modules, with each sub-module constituting the set with the corresponding feature. In the three-dimensional framework, the order of each sub-module constitutes a "Process dimension→Component dimension→ Risk - dimension."

4. Agricultural risk early warning system of indicators and weights

4.1. A system of indicators and measurement

4.1.1. Indicator system

Feature attribute set by the module can be designed to avoid the risk of an early warning indicator system. Feature attribute is determined sub-factor of production. It operates from the bottom to the top, followed by three properties characteristic

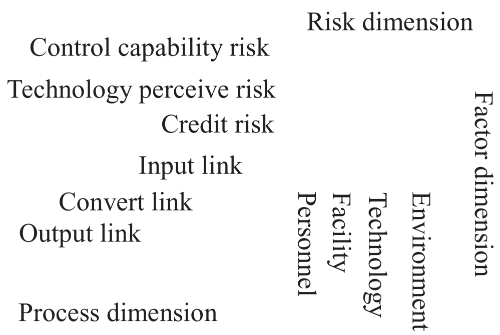

Fig.4. Module three-dimensional framework

property index → 2 → 1 property index p roperty index. To pig breeding "Convert→ Equipment → risk" as an example(Xi Weidong, 2009), the indicator system as shown in Table 1, the table for the tree-like structure, is expressed at the level of feature attributes.

1. Table 1 Breeding equipment and facilities evaluation index system (brief table)

Level	Indicator	Weight
Module Layer	Risk prevention and control ability evaluation indicator of test and sterilizing equipment facilities	0.039
The first level	Evaluation indicator of test equipment	0.500
……	……	……
Module Layer	Evaluation indicator of feeding stuff	0.046
The first level	Evaluation indicator of reusable wrapper	0.450
The second level	Hygiene evaluation indicator of wrapper material	0.340
……	……	……

4.1.2. Index Fuzzy Measurement

Since the majority of properties have a fuzzy nature of the formation of the indicators with an ambiguous assignment, the algorithm is as follows:

1. Target real assignment. Target domain are taken to be the real number field [1, 5];
2. Indicators fuzzy, the formula uses triangular fuzzy numbers

$$\mu_{\tilde{y}}(x) = \begin{cases} (x-c)/(a-c), c \le x \le a \\ (x-b)/(a-b), a \le x \le b \\ 0 \qquad , \quad others \end{cases} \tag{3}$$

$\tilde{y}$ symbolizes the corresponding fuzzy numbers, $\tilde{y} = \tilde{1}、\tilde{2}、\tilde{3}、\tilde{4}、\tilde{5}$ and $\tilde{1}、\tilde{2}、\tilde{3}、\tilde{4}、\tilde{5}$, which shall be respectively low-to high-risk rating.

4.2. Amend-type G_1-model and the index weight

In the G_1-model, based on the amendment proposed in this paper-based G_1-model the algorithm, is as follows:

1. The set of indicators is given in the corresponding ordering relation:

$$x_1^* > x_2^* > \cdots > x_m^* \tag{4}$$

Among them, x_i as an indicator focuses on the first i indicators, x_j^* as the indicators after the concentration of j-month target;

2. To determine between x_{j-1}^* and x_j^* rational judgments

$$\eta_j = \theta_{j-1}/\theta_j \tag{5}$$

3. Experts on the K weight vector $(\theta_{k1}, \theta_{k2}, \cdots, \theta_{km})$, its center of gravity is defined as the $(\theta_1^0, \theta_2^0, \cdots, \theta_m^0)$

$$\begin{aligned} &\min \left(\sum_{k=1}^{K}\sum_{i=1}^{m}(\theta_{ki}-\theta_i^0)^2\right) \\ &s.t. \quad \sum_{i=1}^{m}\theta_i^0 = 1 \\ &\qquad \theta_i^0 \ge 0 \\ &\qquad i = 1,2,\cdots,m \end{aligned} \tag{6}$$

The solution of the problem is:

$$\theta_i^0 = \bar{\theta}_i - \left(\sum_{i=1}^{m}\bar{\theta}_i - 1\right)/m \tag{7}$$

which $\theta_i = (\sum_{k=1}^{K} \theta_{ki})/K$, $i = 1,2,\cdots,m$, $(\theta_1^0, \theta_2^0, \cdots, \theta_m^0)$ is the weights of dedicators $\{x_i/i = 1,2,\cdots,m\}$. The calculated results of an example are shown in Table 1.

5. Method of frequency of membership degree and Risk warning

5.1. Method of frequency of membership degree

This method is definite like this: it regards membership degree of fuzzy aggregation as classic aggregation rate, replaces risk grade rate with sum of figures of the membership degrees, and in which the maximum sum is named as Plural. The calculation process is as follows:

1. Input sample vector of the membership degree $\vec{\mu}_i = (\mu_{i\tilde{1}}, \mu_{i\tilde{2}}, \mu_{i\tilde{3}}, \mu_{i\tilde{4}}, \mu_{i\tilde{5}})$, calculate the sum of risk grade rate; $\mu_{\tilde{y}} = \sum_{i=1}^{n} \mu_{i,\tilde{y}}$;

2. Calculate the maximum sum of membership degrees $\mu^* = \max_{\tilde{y}} \{\mu_{\tilde{y}}\}$, so the vector μ^* 's corresponding risk grade is Plural.

5.2. Risk warning

5.2.1. Risk grade and its membership function

The Risk warning contains four grades, whose corresponding Triangular fuzzy number is curtained by the formula (3) and Fig. 5. In this figure, the risk level is higher from 1 to 5, and the 5th grade is safe.

5.2.2. Risk warning

Risk warning contains production elements warning, unity warning, and regional warning. Production elements warning is in connection with the risk level for each module. Unity warning is with the risk integrative level for the whole module in producer's individual. At last, regional warning is to the individual in some range of space.

1. The warning calculation method. The specific progress is as follows:

(1) Input the indicator x, and blur the index with formula (3).

(2) Integrate the up-level indicator according to the formula (8):

$$\vec{X}^{(n)} = \vec{\theta}^{(n-1)} \oplus \vec{X}^{(n-1)} \qquad (8)$$

In this formula, $\vec{X}^{(n)}$ represents the index in the *n* level, to the degree of each risk grade subjection. $\vec{\theta}^{(n-1)}$ Represents weight vector of each index in the *n-1* level. $\oplus$ means indicator synthetic algorithm.

(3) Module warning Risk warning grade is defined according to max $(\vec{X}^{(N)})$.

Individual warning method is the same as above.

2. Regional warning method. It makes an unity evaluation $\vec{X}^{(N)}$, according to the Frequency of subjection degree method. We can get the sampling farmers μ^* ,and then get the fuzzy Plural., which is the basis of warning decision.

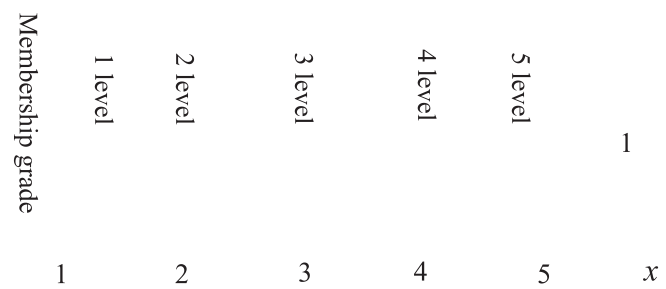

Fig.5. Early-warning indicators threshold and corresponding figure of risk level

6. Conclusion

Basing on the fuzzy-rough set theory, we have drawn the knowledge and regulation about risk of pig production quality, and revealed the risk formation mechanism with "2-3 structure" in the risk system. According to this, we have constructed the three-dimensional mode of danger analysis and its module system of the primary products. The paper puts forward the weight of index assignment amendment G1-model and area warning "subjection degree frequency method". This method is applicable for producers, sellers and supervisors of each connection in the agricultural production chains.

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